

Monitoring and Forecasting Cyanobacterial Blooms for Public Health Protection and Response

NASA - Decision Support through Earth Science
NNH08ZDA001N-Decisions

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MD DNR.

Lake Erie 22 July 2011

Why worry about cyano HABs?

- ❖ Degrades water quality
 - ❖ Taste/odor issues
 - ❖ Loss of recreational and fishing value to affected waters
 - ❖ Hypoxia/anoxia, may lead to mortality in benthic invertebrate community and fish kills
- ❖ Alters food webs
 - ❖ Unpalatable to many zooplankton grazers
- ❖ Toxin producer
(neurotoxins, hepatotoxins, dermatotoxins)
 - Toxic to zooplankton, shellfish, fish, animals, humans

Dogs have been known to die of renal failure within hours of drinking water with microcystins.

The health perspective

Ohio, 2010, 48 human illnesses, 5 dead dogs, closure of YMCA lake near (1000 ppb microcystin 19 kids sick, Silver Lake, Ohio, 2010). Posting Grand Lake St Marys MD Girl Scout camp lost the use of its Lake Williston in 2009-10 from *Microcystis* blooms. Lake drained & treated (2011)

WHO standard for microcystin, 20 ppb; no US standard; and no std for other toxins.

Cyanobacteria blooms in Lake Erie this century, a satellite perspective



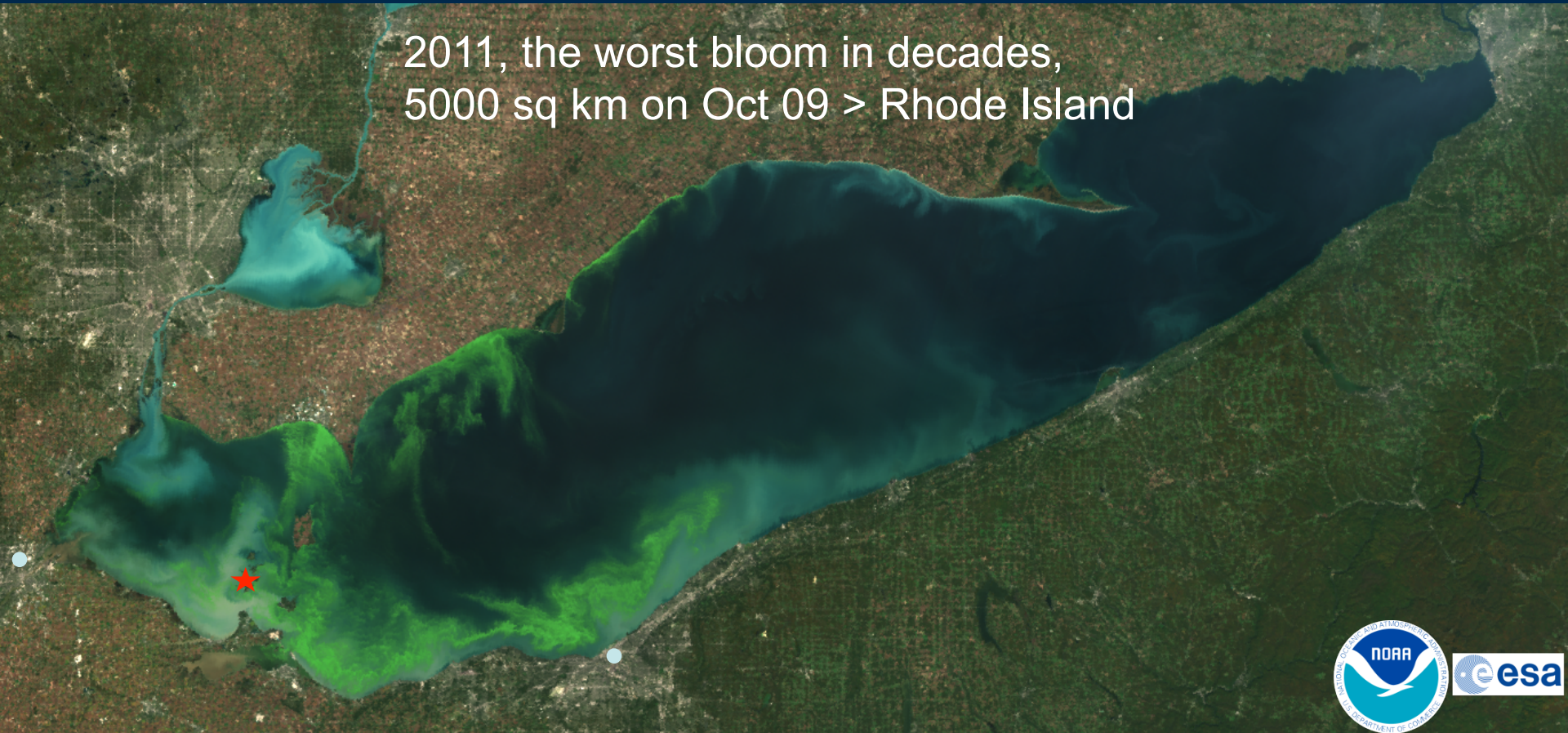
In 2005, the 2003 bloom was described as “perhaps the most severe in Lake Erie’s recent history” (EPA)

www.epa.gov/med/grosseile_site/indicators/algae-blooms.html

18 August Landsat, data from OhioView

2011 cyanobacteria bloom

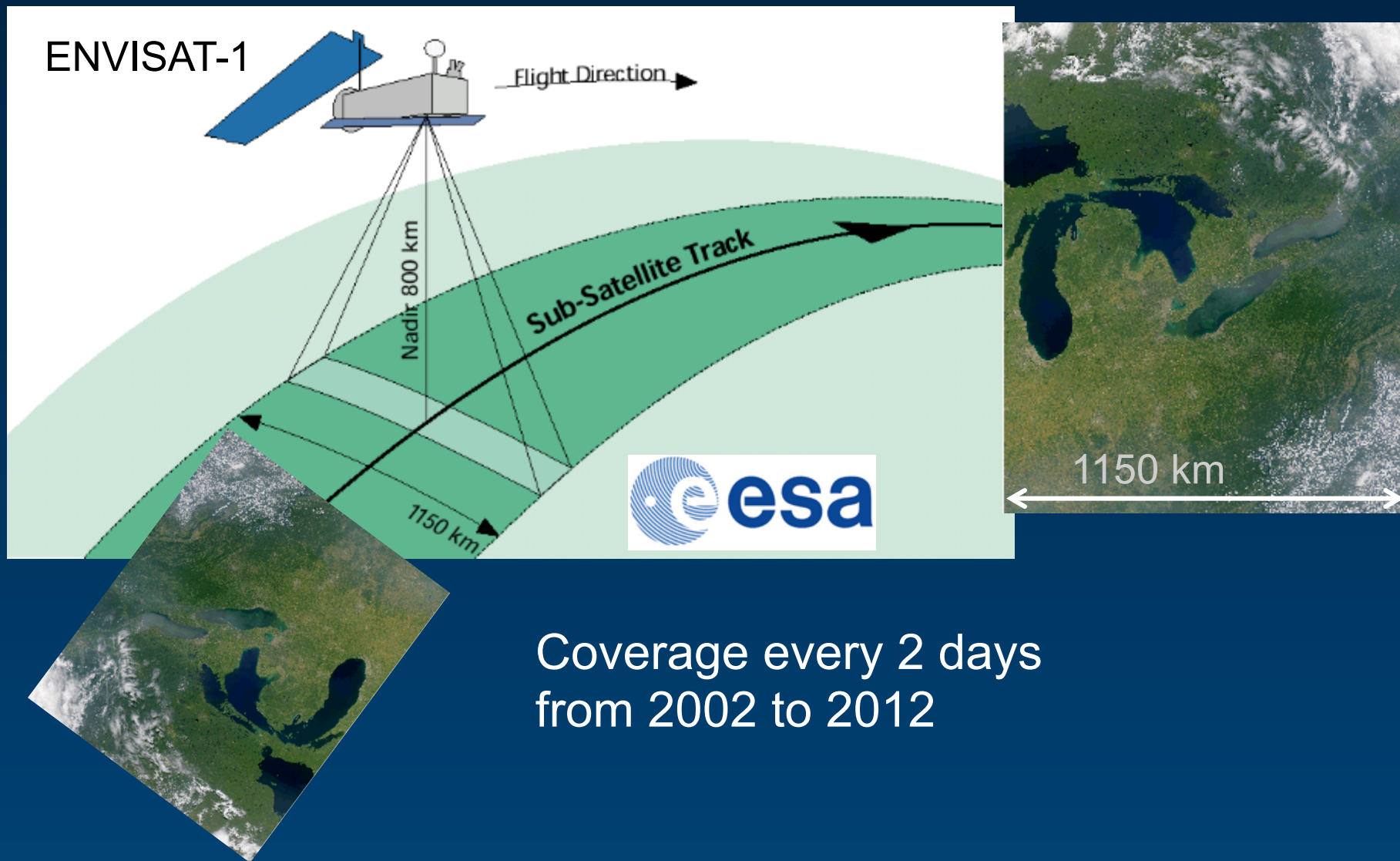
2011, the worst bloom in decades,
5000 sq km on Oct 09 > Rhode Island



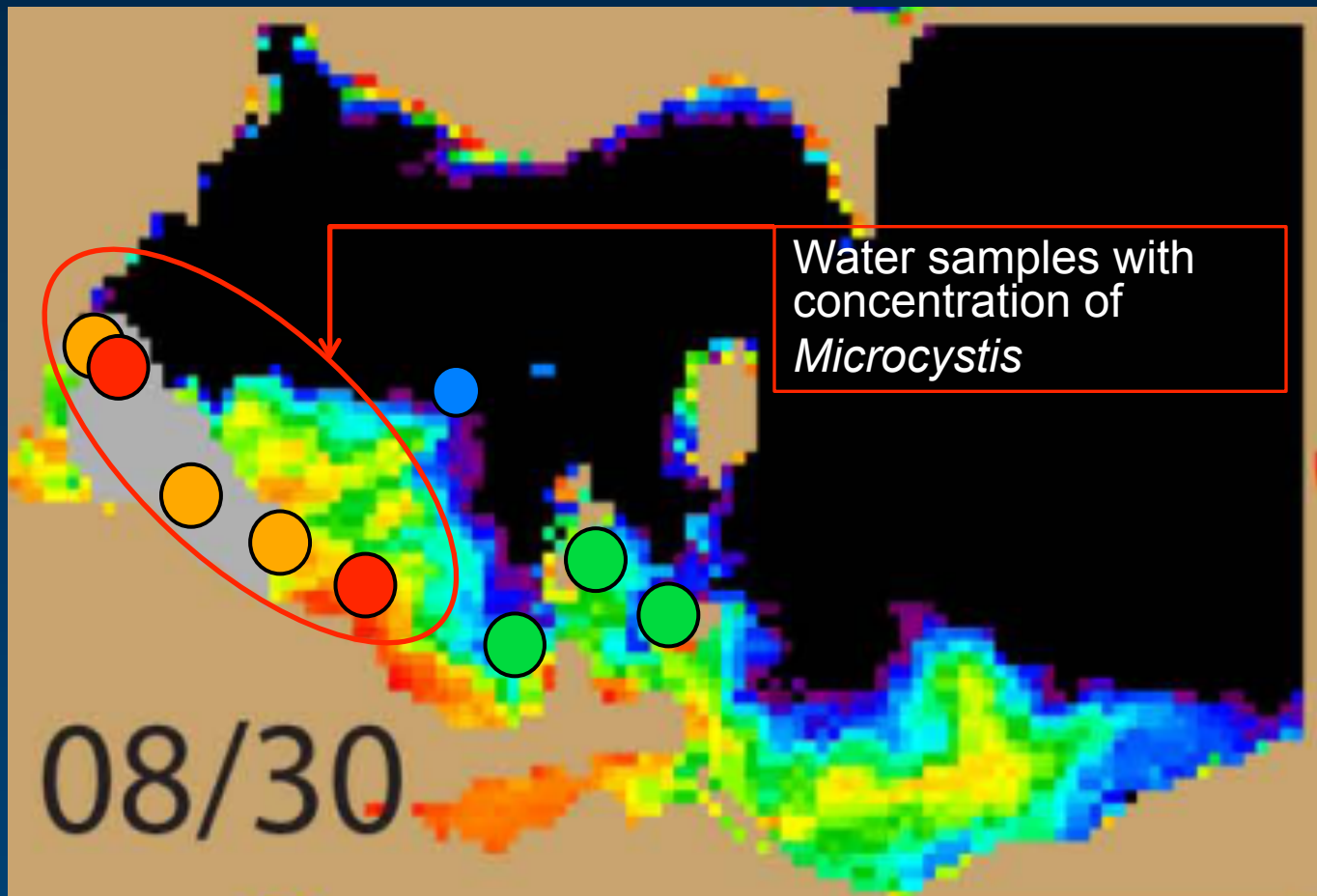
09 October : Data from MERIS
(European Space Agency)



MERIS on the ENVISAT-1 satellite



Confirm and quantify bloom in field (role of OSU Stone Lab this summer)



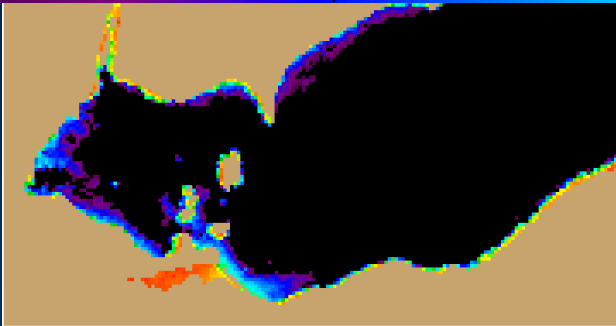
MERIS data from ESA

10 years of MERIS data, we have now mapped the peak of bloom for each year

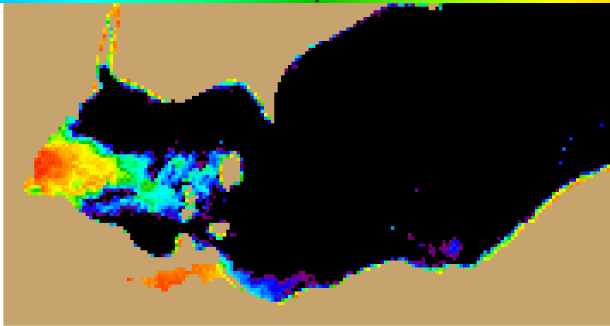
0.0002

0.001

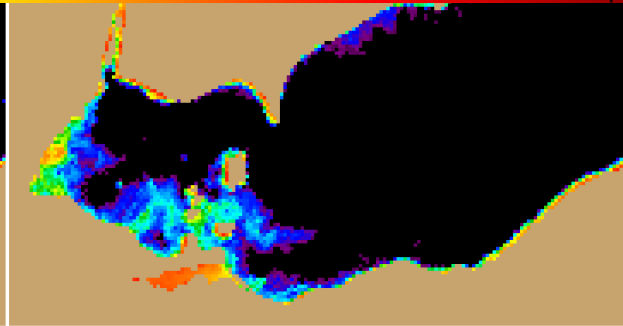
0.01



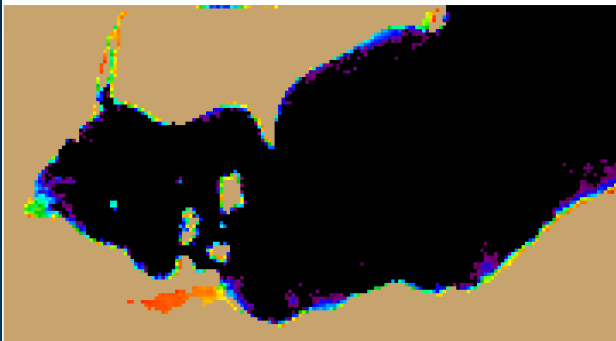
2002



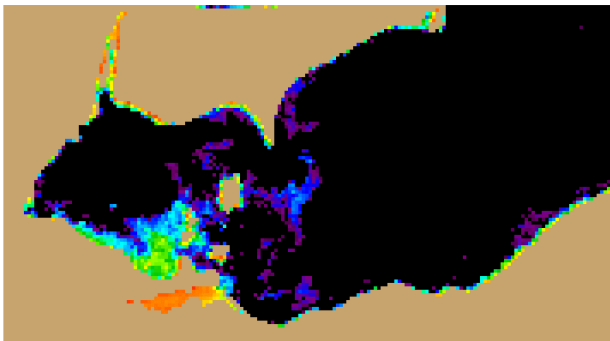
2003



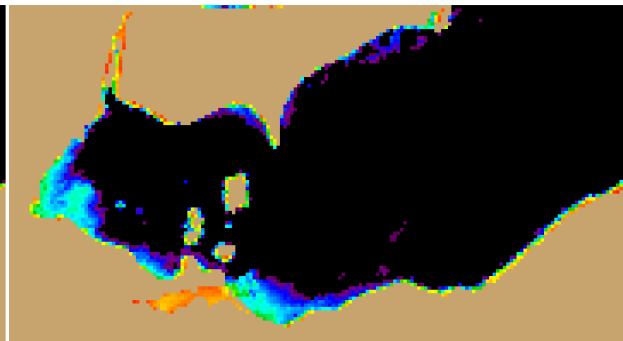
2004



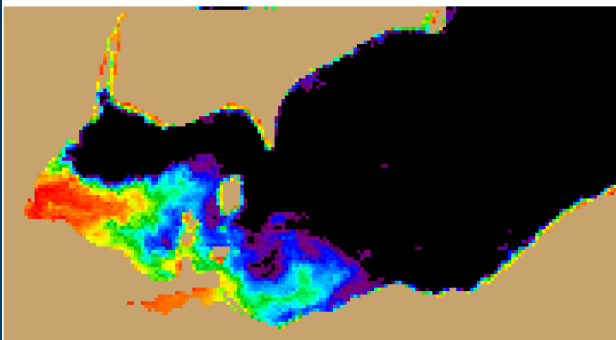
2005



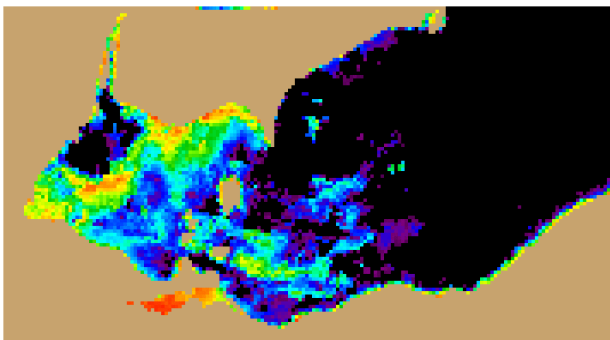
2006



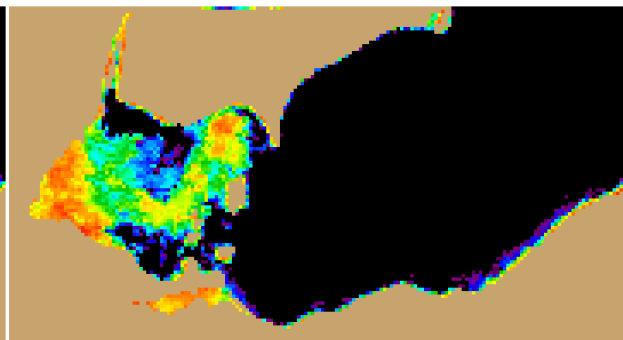
2007



2008



2009



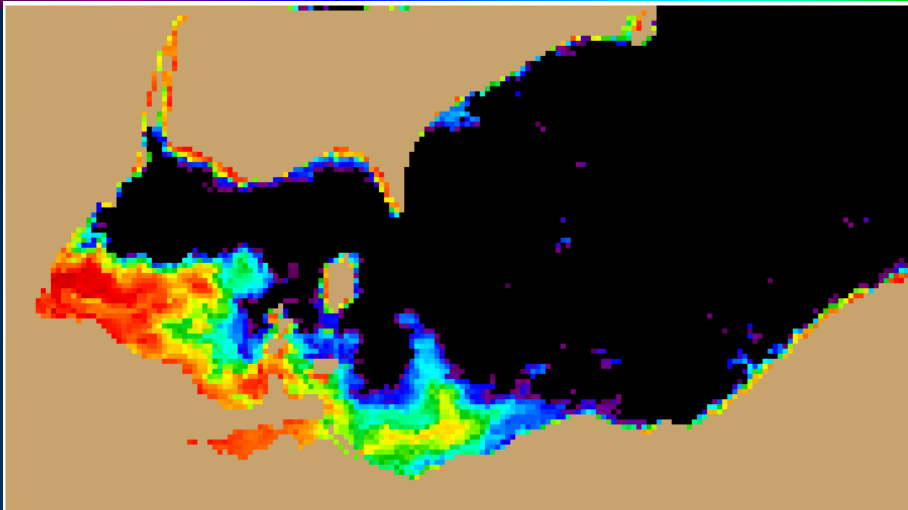
2010

Peak of bloom, four worst years: 2008-2011

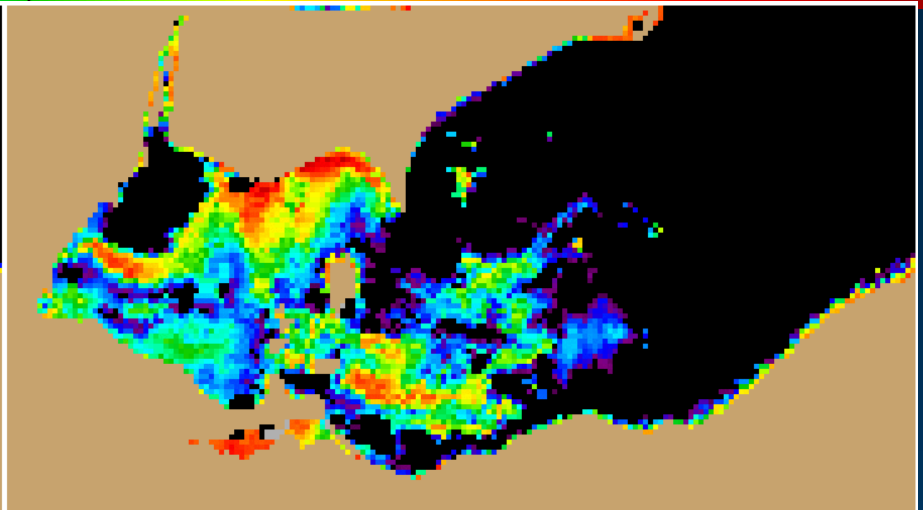
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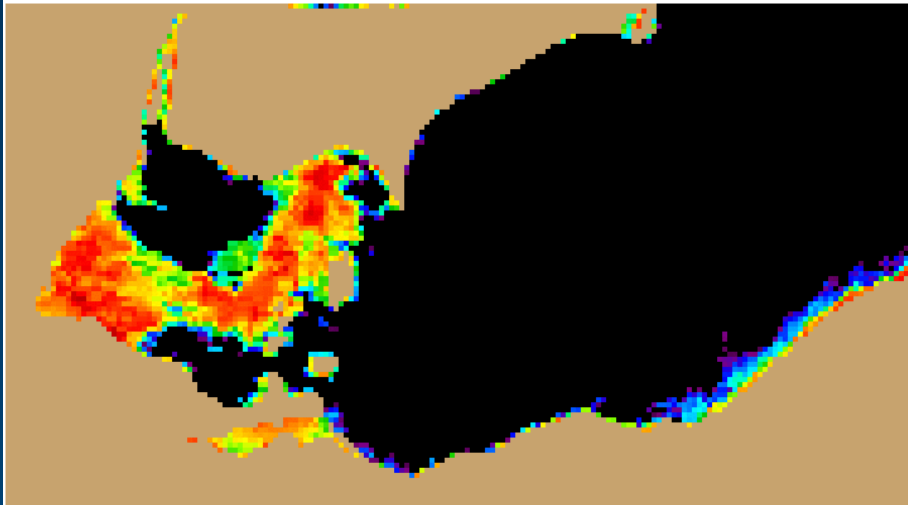
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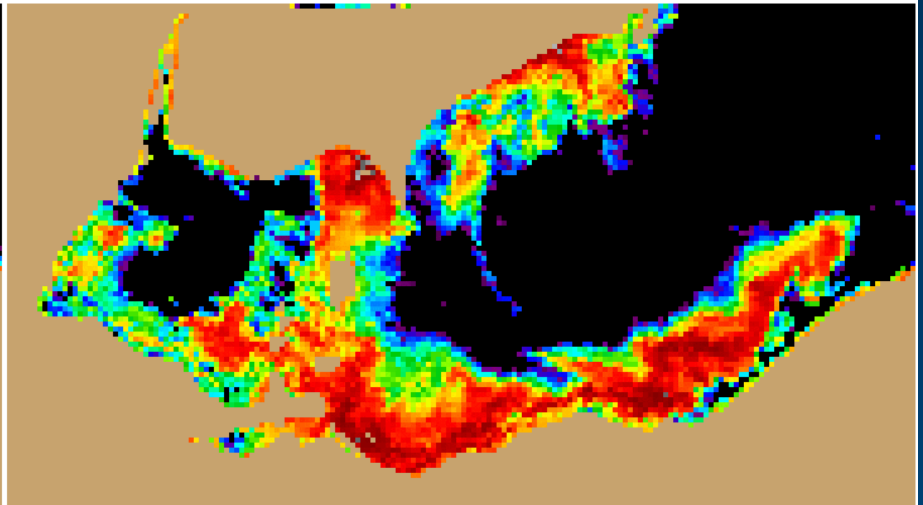
2008



2009

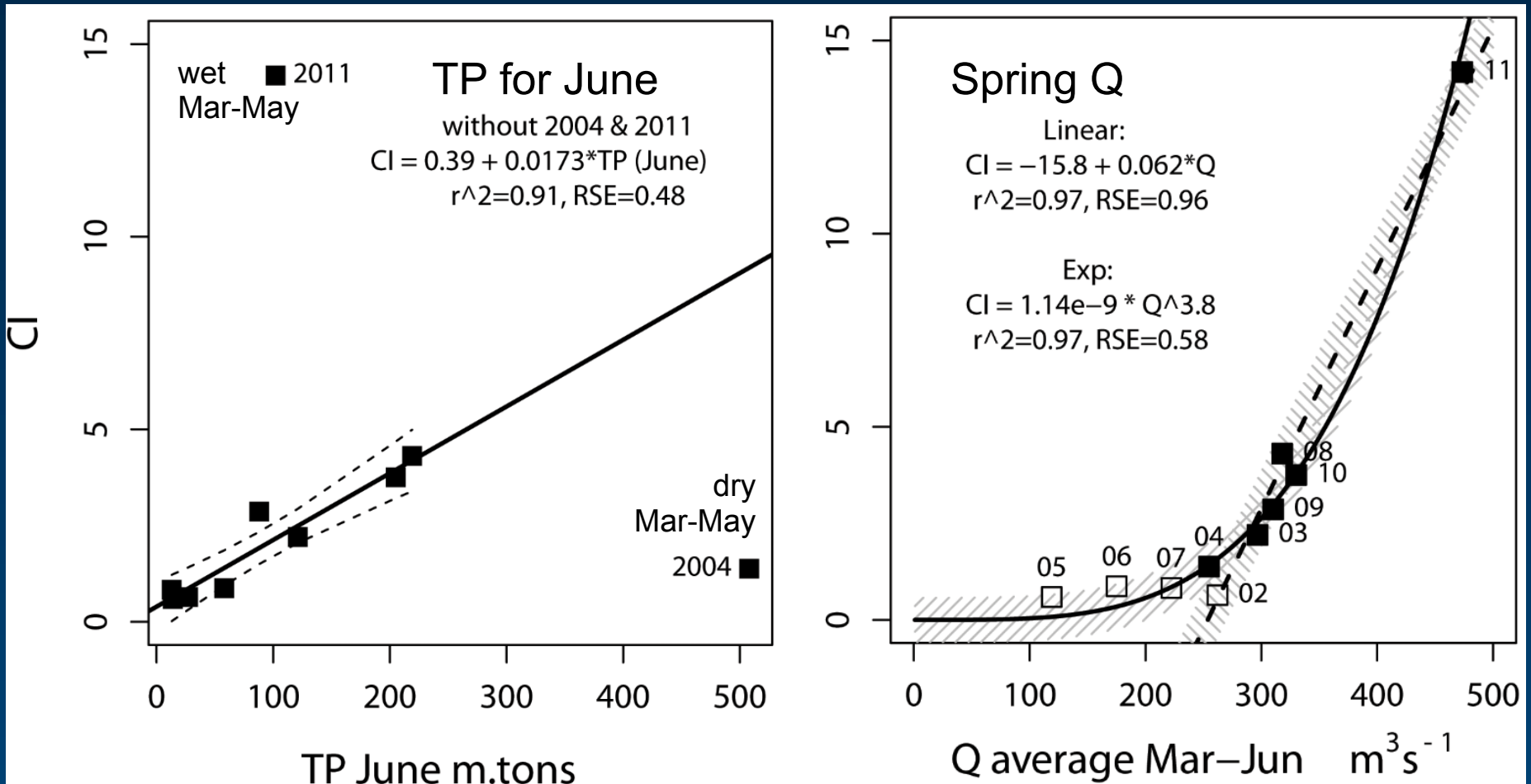


2010



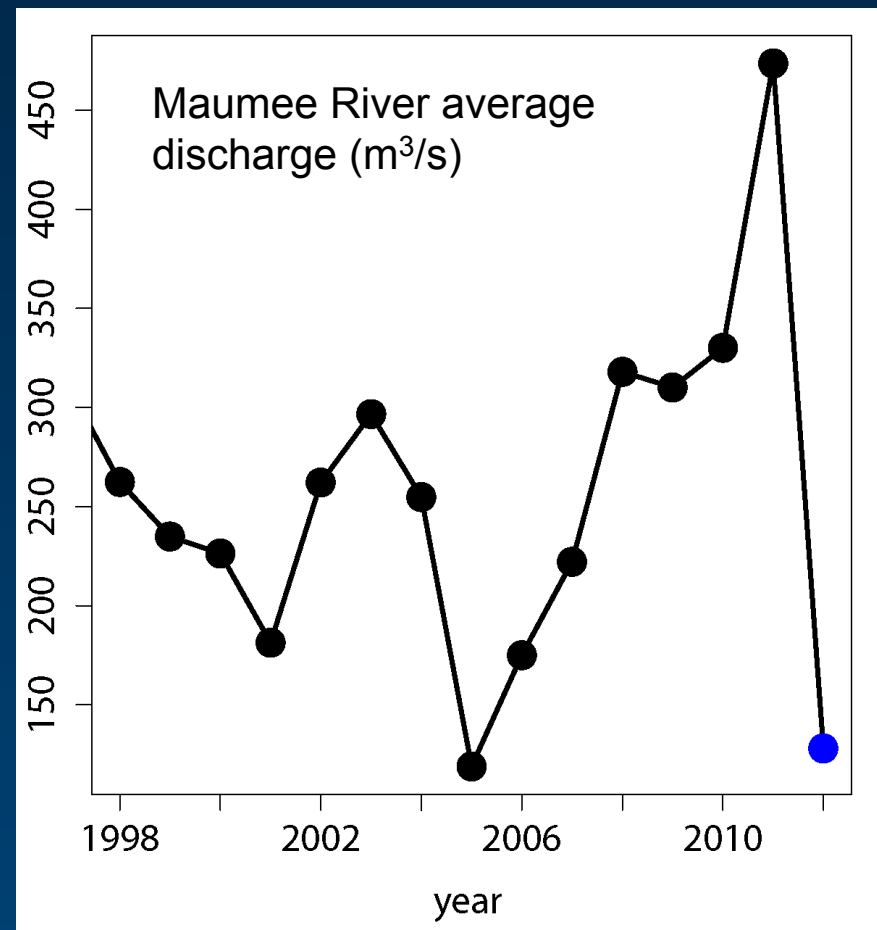
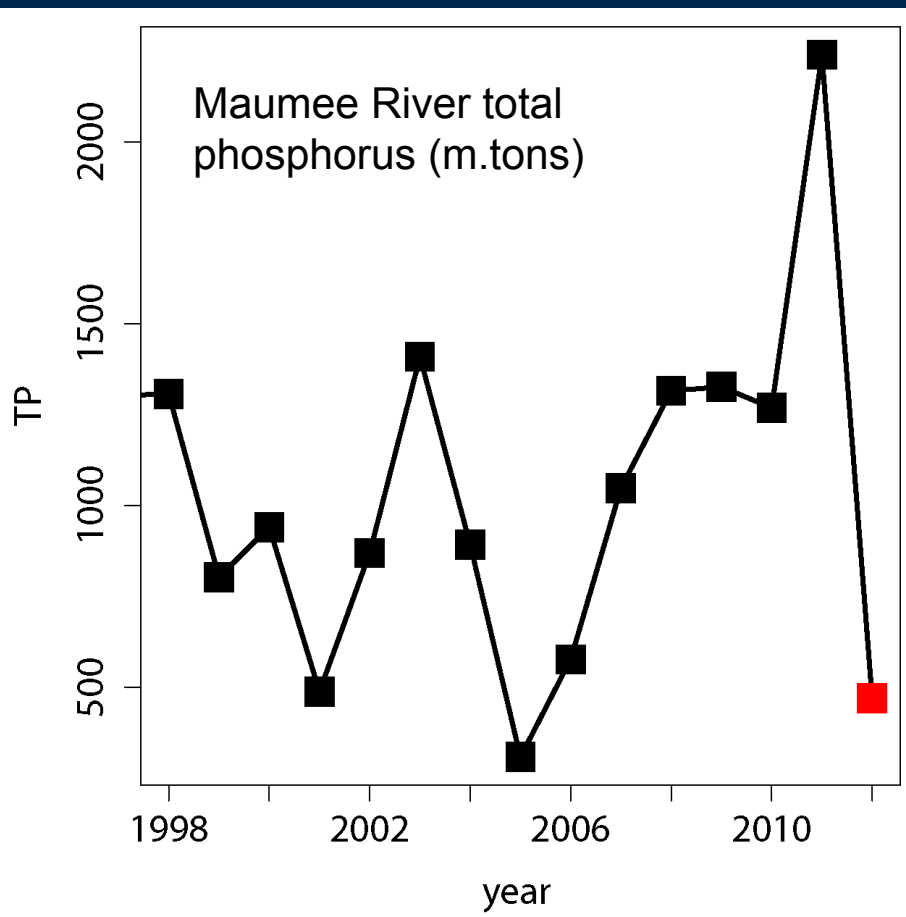
2011

We have established the long-suspected link of blooms to Maumee River. Spring discharge and June TP drive cyano-bloom intensity

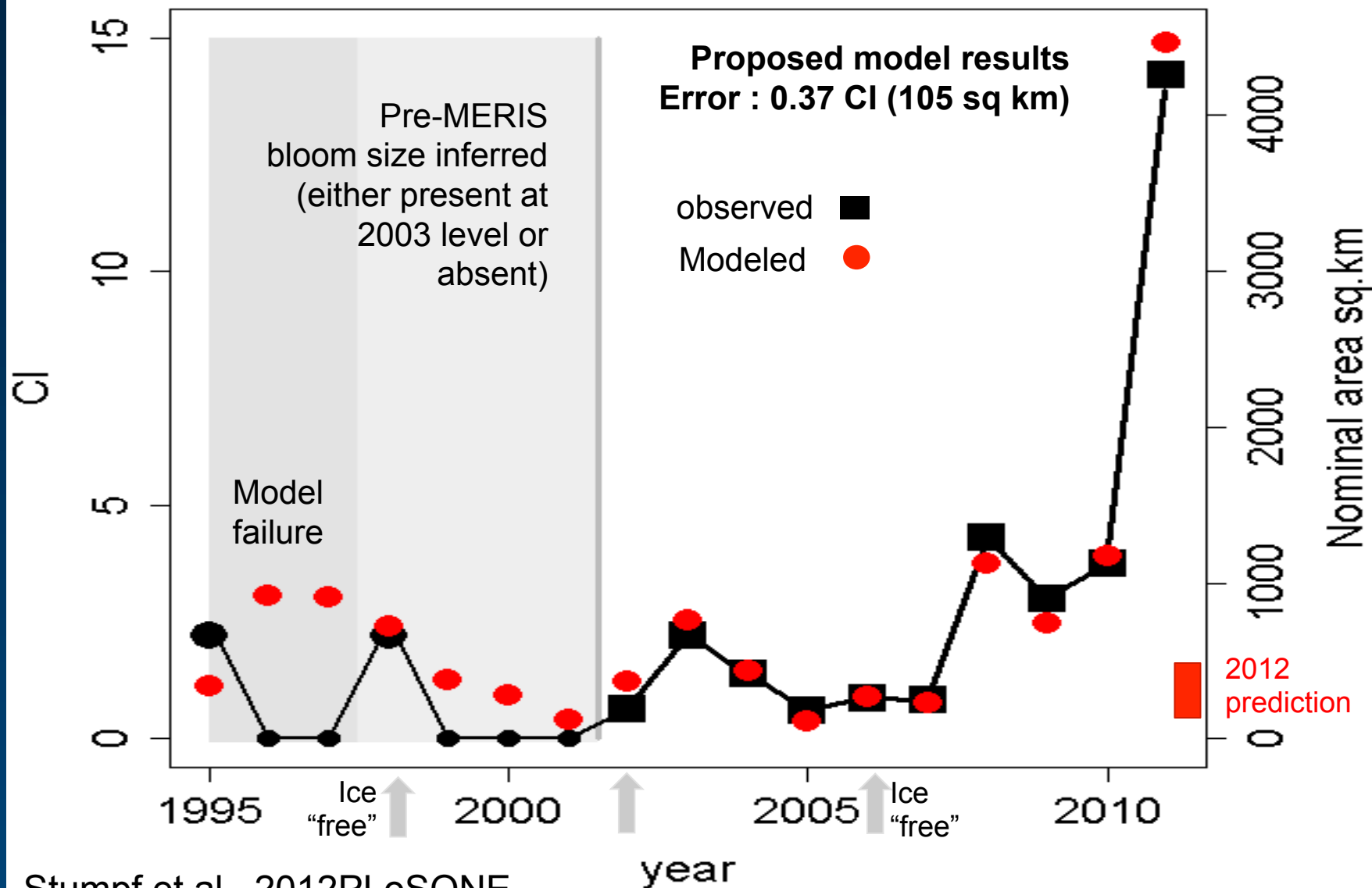


Stumpf et al., 2012, PLoS ONE.

2012: dry spring and low loads Equivalent to 2005 to 2007

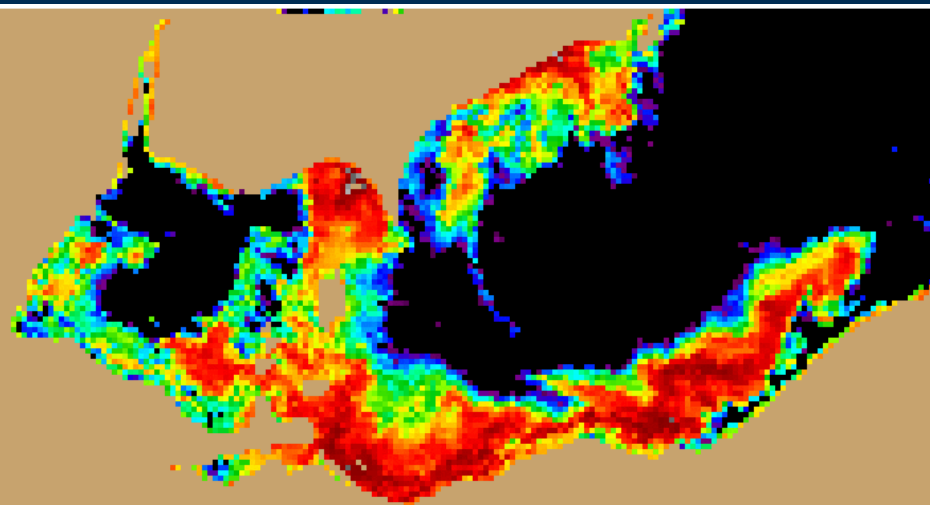


Spring (Mar-Jun) explains annual bloom intensity; a lag between P supply and the bloom

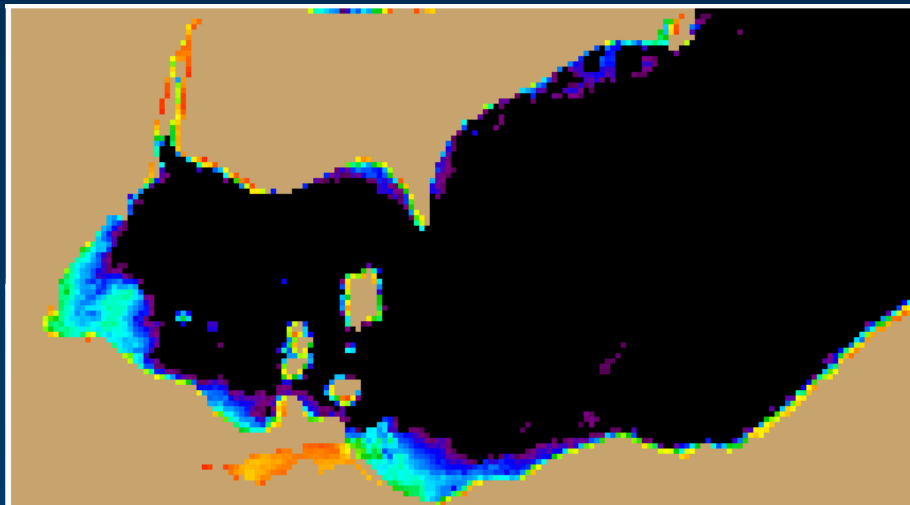


Stumpf et al., 2012 PLoS ONE.

**On July 5, we made the 2012 prediction for
western Lake Erie
*a mild bloom, < 1/10 of 2011, close to 2007***



2011



2007

low

medium

high

concentration

2012: First prediction for Lake Erie announced at Stone Lab, Ohio, July 05. Press attended



Friday, July 6 2012 3:23pm

Forecast predicts mild Harmful Algal Bloom

The National Oceanic & Atmospheric Administration's National Centers for Coastal Ocean Science issued the first-ever seasonal harmful algal bloom forecast for Lake Erie at an all-day press event Thursday at Ohio State University's Stone Laboratory. The forecast predicts a mild bloom, similar to conditions last seen in 2007 and about one-tenth the size of last year's bloom.

"A mild bloom is great news for this year," said Dr. Jeffrey Reutter, Director of Ohio Sea Grant and Stone Laboratory. "But this is happening because we're in a drought, not because phosphorus loading to Lake Erie has improved. If we have a real wet spring in 2013, we could be right back to where we were."

Researchers
predict smaller
Lake Erie algae
bloom

[ASSOCIATED PRESS](#)



Milestones and Results year 3

Data:

- MERIS lost in April

- Developed/evaluated MODIS 1-km algorithm in May

Predictions & Climate:

- First ever of bloom severity, Lake Erie, public announcement with Ohio Sea Grant, July 5th.

- Nutrient linkage narrowed to spring, impact on Lake nutrient mgmt discussions

Forecasts:

- Monitoring of Lake Erie, starting June with MODIS

- Discussions across NOAA on formal creation of robust forecast system.

Milestones and Results year 3

Product distribution:

Maryland and Florida want products, on hold because of MERIS/MODIS issue

Web site built for improved image product distribution

EPA funded a 1-year project to design smartphone distribution option of satellite bloom data to mgrs

Product Type:

Validation continuing

Collaboration with EPA on national MERIS validation

Budget

IAG and contracts are slow. Year 3 expenditures just starting.

Year 4 IAG is still ongoing in NOAA.

Will need one-year extension for our associated contracts.

Change of personnel and changes in CDC will alter the mix somewhat from proposal (previously noted in year 3).

Risks

Loss of MERIS:

Loss of bloom discrimination and resolution has concerned partners. We got MODIS to deliver quantity at 1-km, it cannot give discrimination.

Working on assumption of OLCI/Sentinel-3 in 2014.

Assuring partners of this. **(one year extension will make this possible.)**

CDC engagement unclear after 2013 (EH tracking is possible)

US EPA now investing in distribution. US Army Corps of Engrs is interested. NOAA is writing a formal ecological forecast system plan.

These may lead to alternative paths to operations.

ARL's

Start: ARL = 2 (Application components and decision making identified).

Current: ARL 6-8: Prototype demonstrated and being used by end-users (Forecasts Ohio, Florida HAB bulletin, MD image distribution).

ARL 8: User training and documentation.

Goal: ARL 8-9: Approved by end-user for decision making. Expect sustained use.



**Experimental
Lake Erie Harmful Algal Bloom Bulletin**
2011-007
22 July 2011
National Ocean Service
Great Lakes Environmental Research Laboratory
Last bulletin: 14 July 2011

Conditions: There appears to be a bloom of cyanobacteria in western Lake Erie. The bloom has not been validated with in situ sampling.

Analysis: This image is from Saturday. The wind stress has been low and water temperature has been high so the bloom is most likely still at the surface and conditions are favorable to gain biomass. Forecast transport shows a slight NE movement.

-Wynne

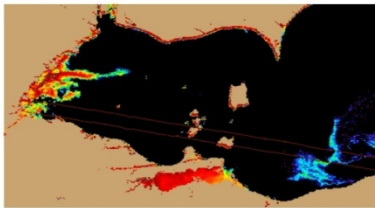


Figure 1. MERIS image from the European Space Agency. Imagery shows the spectral shape at 681 nm from July 16, where colored pixels indicate the likelihood of the last known position of the *Microcystis* spp. bloom (with red being the highest concentration). *Microcystis* spp. abundance data from shown as white squares (very high), circles (high), diamonds (medium), triangles (low), + (very low) and X (not present).

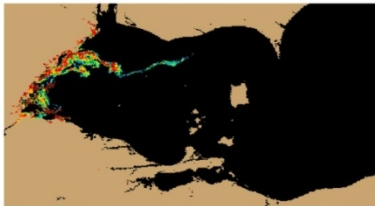


Figure 2. Nowcast position of *Microcystis* spp. bloom for July 22 using GLCFS modeled currents to move the bloom from the July 16 image.

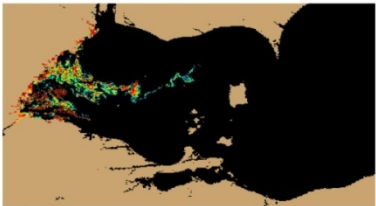


Figure 3. Forecast position of *Microcystis* spp. for July 25 using GLCFS modeled currents to move the bloom from July 16 image.

Please note:

- MERIS imagery was distributed by the NOAA CoastWatch Program and provided by the European Space Agency
- http://www.glerl.noaa.gov/res/Centers/HABS/lake_erie_hab/lake_erie_hab.html
- Cell counts were collected by the Great Lakes Environmental Research Laboratory
- The wind data is available through the National Data Buoy Center and the National Weather Service
- Modeled currents were provided through the Great Lakes Coastal Forecasting System



22 July 2011, western Lake Erie



Lake Erie Bulletin, 2011, 3rd year

Experimental Lake Erie Harmful Algal Bloom Bulletin

2011-008

08 September 2011

National Ocean Service

Great Lakes Environmental Research Laboratory

Last bulletin: 22 July 2011

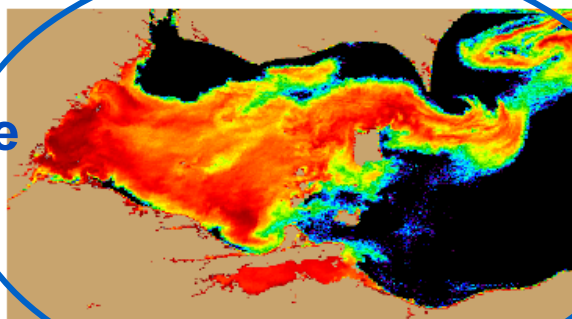


Figure 1. MERIS image from the European Space Agency. Imagery shows the spectral shape at 681 nm from September 03, where colored pixels indicate the likelihood of the last known position of the *Microcystis* spp. bloom (with red being the highest concentration). *Microcystis* spp. abundance data from shown as white squares (very high), circles (high), diamonds (medium), triangles (low), + (very low) and X (not present).

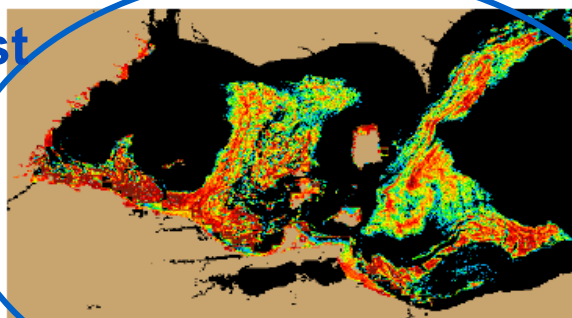


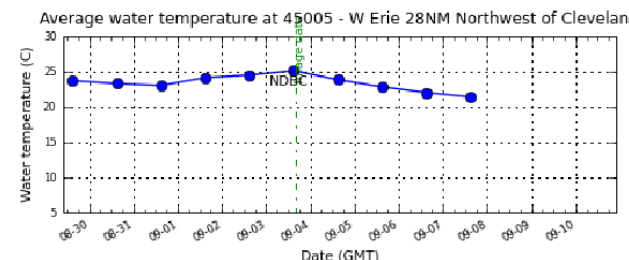
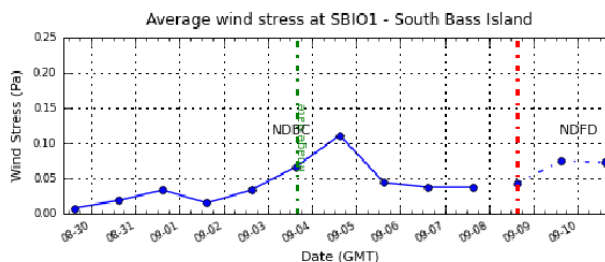
Figure 2. Nowcast position of *Microcystis* spp. bloom for September 08 using GLIFS modeled currents to move the bloom from the September 03 image.

Conditions: A massive *Microcystis* bloom persists throughout most of Lake Erie's Western Basin.

Analysis: As indicated in satellite imagery from Saturday (9/3/2011), an enormous *Microcystis* bloom was present in western Lake Erie. The southern extent of the bloom was remotely observed along the coast of Ohio from Maumee Bay to Catawba Island. The northern extent of the bloom was observed to be consistent along the Michigan coast from Northern Maumee Bay to the mouth of the Detroit River. The eastern-most portion of the bloom was observed past Point Pelee and to the northeast up in to Rondeau Provincial Park.

At the mouth of the Detroit River, a five day nowcast shows a southward suppression of the western-most portions of the bloom. However, the bloom is likely to still persist in much of the Western Basin. The nowcast also suggest the bloom has spread to the east of Sandusky and into the Cleveland area. (Note: Due to a lack of clear imagery the bloom has not been remotely observed in the Cleveland area.) A three day forecast also suggests that the bloom will persist to the north of Cleveland through the weekend. Water temperatures remain above 20 degrees Celsius and are forecast to decrease into the weekend; however, conditions remain favorable for bloom growth.

Bridge Wyoona



GREAT LAKES ECHO

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Satellite system warns swimmers, treatment plants of harmful algae

JUL 12 2011 SHAHEEN KANTHAWALA 3 COMMENTS

Satellite images of Lake Erie sent right to your inbox can warn you about harmful algae in the lake before you decide to visit.

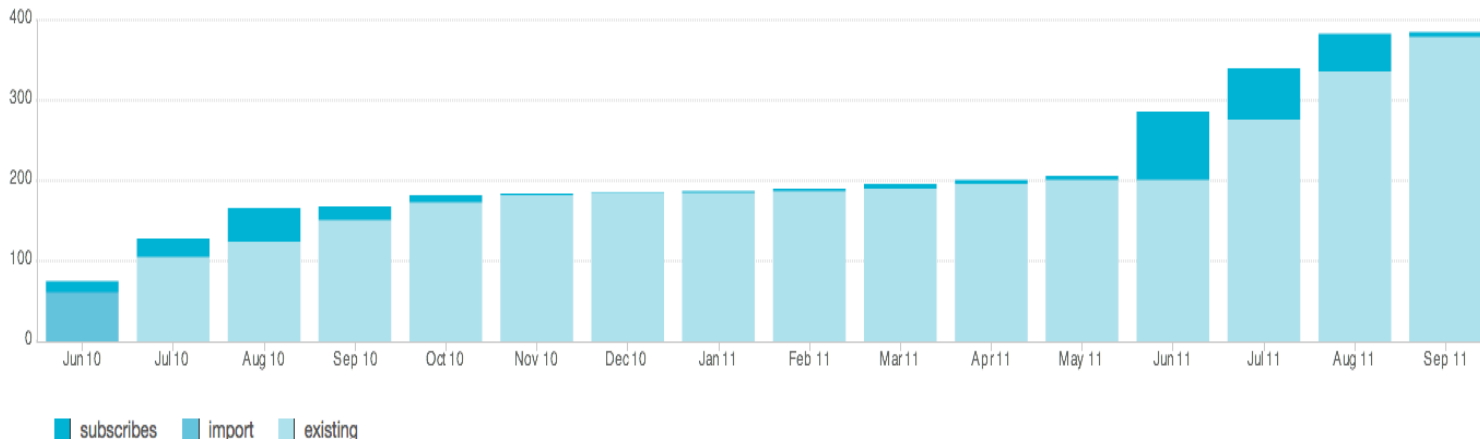
People can [sign up](#) for the emailed bulletin that was developed at the Center of Excellence for Great Lakes in Human Health at the National Oceanic and Atmospheric Administration.

They'll learn where waves, winds and currents are expected to move algal blooms, said Sonia Joseph Joshi, Excellence for Great Lakes in Human Health.



Satellite
Space
of the
-high,
Nation

List Growth



Broad Interest in bulletin

Currently almost
500 subscribers

the Atlantic

Blue-Green Algae: Iridescent but Deadly

By Jessica Marshall
Sep 18 2012

Media hits



PortClinton
NewsHerald.com

Algae makes its way to Kelleys Island

Aug 27, 2011

KELLEYS ISLAND --The Kelleys Island State Park's public beach includes a posted warning about the algae bloom that has made its way to the island's north side.

"They are a blue-green algae, and we call them harmful algae blooms because they produce a toxin called microcystin," said Sonia Joseph-Joshi, outreach coordinator for the National Oceanic and Atmospheric Administration's Center of Excellence for Great Lakes and Human Health.

In Asia and South America, she said, the toxins in blue-green algae have caused deaths after being ingested.

At an Ohio Lake Erie Commission meeting in June, researchers predicted a thicker, longer-lasting algal bloom than seen in past years, because of heavier than normal rains. Those rains are blamed for transporting high levels of fertilizer and phosphorous from agricultural fields into small streams and, eventually, into Lake Erie.

"There are three major rivers," Joseph-Joshi said, "the Maumee, Detroit and Sandusky, and they all converge in western Lake Erie."

According to researchers, those rivers and others are pouring tens of thousands of tons of nutrients into the lake each year, feeding the algae blooms.

Mike Libben, a technician with the Ottawa Soil and Water Conservation District, said his organization works hard to educate and help change the habits of people who work in agriculture.

GREAT LAKES ECHO

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Satellite system warns swimmers, treatment plants of harmful algae

JUL 12 2011

SHAHEEN KANTHAWALA

3 COMMENTS

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Satellite images of Lake Erie on June 07, 2011, from MERIS - the European Space Agency. The different colors show the likelihood of the last known position of the Microcystis bloom (where red- highest, white squares -very high, circles -high, diamonds -medium, triangles -low, + -very low and X -not present). Image: National Oceanic and Atmospheric Administration.

2012 monitored with MODIS. Surprise bloom in central Lake Erie



Experimental Lake Erie Harmful Algal Bloom Bulletin

National Centers for Coastal Ocean Science and Great Lakes Environmental Research Laboratory

11 July 2012; Bulletin 6

Imagery and field observances from earlier this week indicate high concentrations of *Anabaena* and some *Microcystis* in the central basin. Models indicate slight northwest movement over the next three days.

- Dupuy, Briggs, Wynne

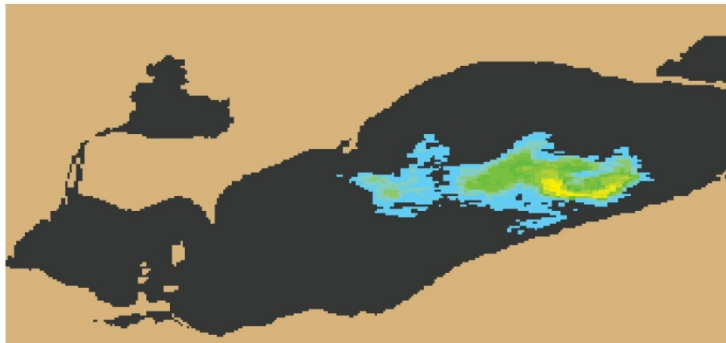


Figure 1. MODIS Cyanobacterial Index from 10 July 2012.

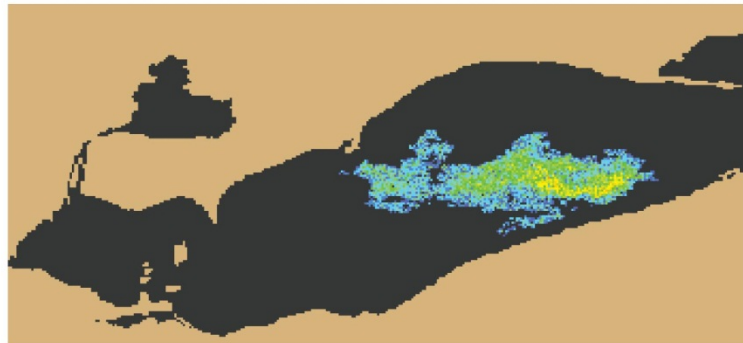


Figure 2. Nowcast position of bloom for 11 July 2012 using GLCFS modeled currents to move the bloom from the 10 July 2012 image.

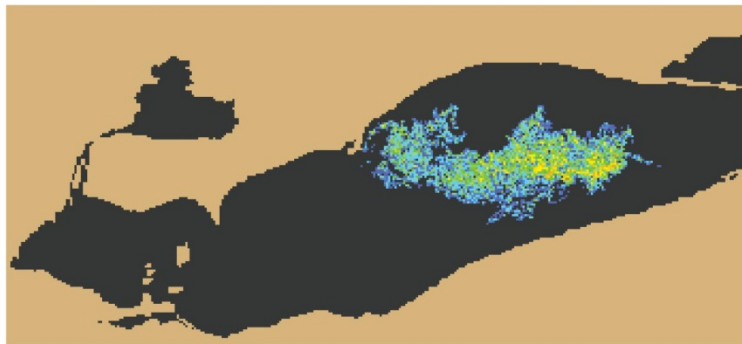
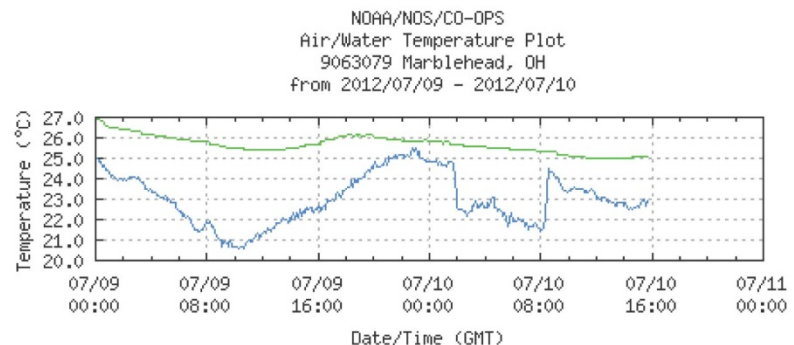


Figure 3. Forecast position of bloom for 14 July 2012 using GLCFS modeled currents to move the bloom from the 10 July 2012 image.



water temp. — air temp. —
Air and Water Temperature from Marblehead, OH. From:
NOAA/Center for Operational Oceanographic Products and Services

Western Lake Bloom is small this year. Monitoring and validation with MODIS. Now involved in mgmt of nutrient loads.



Experimental Lake Erie Harmful Algal Bloom Bulletin

National Centers for Coastal Ocean Science and Great Lakes Environmental Research Laboratory

5 September 2012; Bulletin 14

In Maumee Bay, U.Toledo reports that *Anabaena* has replaced *Microcystis*. The imagery shows the bloom has slightly weakened since last week's bulletin. The model forecasts for a S SE movement.

- Dupuy, Wynne, Briggs



Figure 1. MODIS Cyanobacterial Index from 3 September 2012.



Figure 3. Forecast position of bloom for 8 September 2012 using GLCFS modeled currents to move the bloom from the 3 September 2012 image.

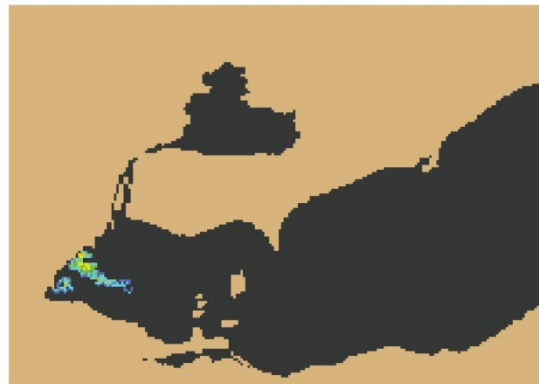
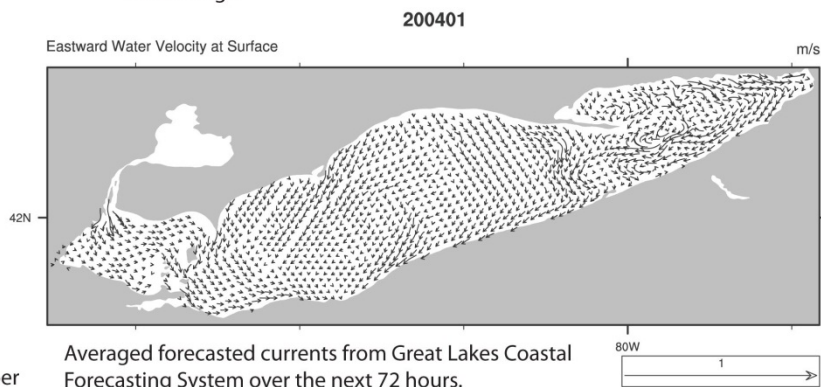
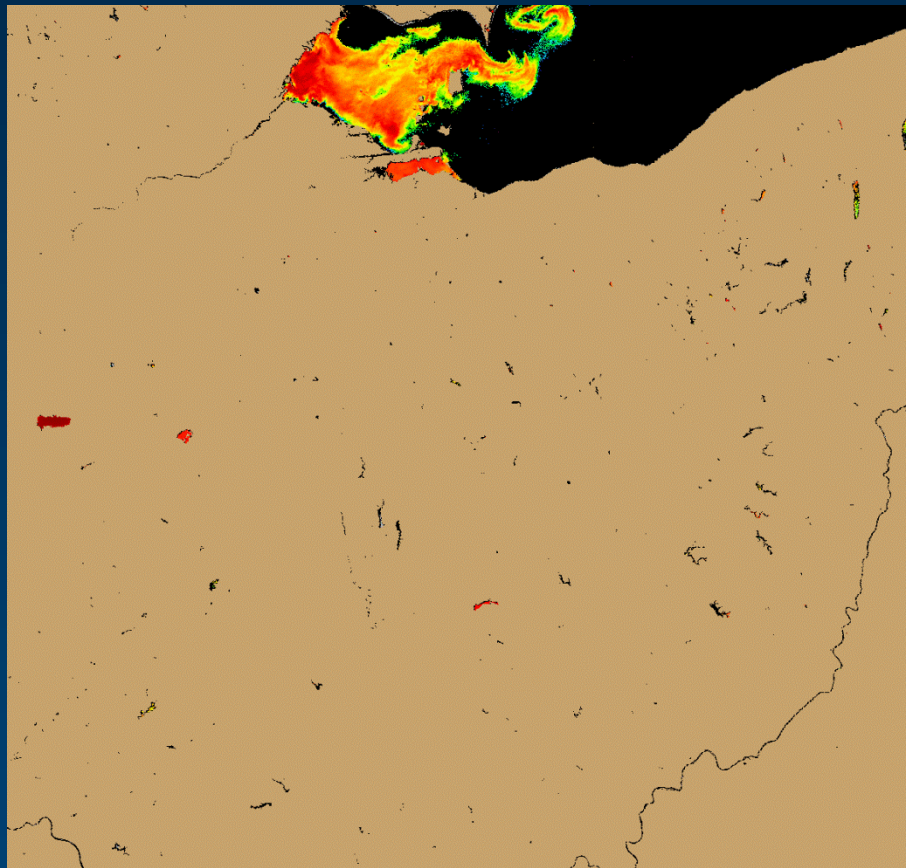


Figure 2. Nowcast position of bloom for 5 September 2012 using GLCFS modeled currents to move the bloom from the 3 September 2012 image.



Averaged forecasted currents from Great Lakes Coastal Forecasting System over the next 72 hours.

The rest of Ohio: Ohio EPA wants more info on other lakes. Sampled for validation in Sep 2011. Also discussions with USACE.



Field sampling

❖ 2012 sampling

- ❖ Monthly and event response
- ❖ Stations throughout western Lake Erie, including drinking water intakes

❖ Samples collected

- ❖ Cell counts – major HAB species
- ❖ Microcystin
- ❖ Phycocyanin (pigment indicator of cyanobacterial HABs)
 - PC fluorescence sensor
- ❖ Chlorophyll a, Secchi depth

Florida Department of Health (FDOH) Aquatic Toxins Disease Prevention Program

Satellite Health Bulletin

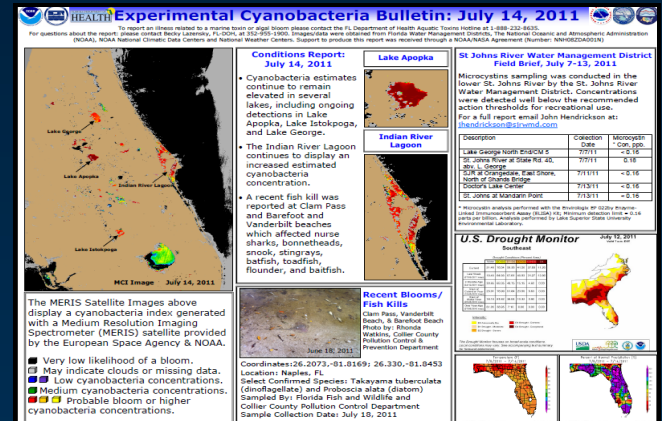
Becky Lazensky, MPH

Andrew Reich, MS, MSPH

- FDOH developed a satellite health bulletin to disseminate satellite imagery data and interpretation to users on a routine basis
- Bulletins contain MERIS satellite images with interpretation, a section on recent algae blooms, a HABs and health section, and field observations
- Reports are produced on a bi-weekly basis when MERIS satellite images are available



Florida Satellite Health Bulletins



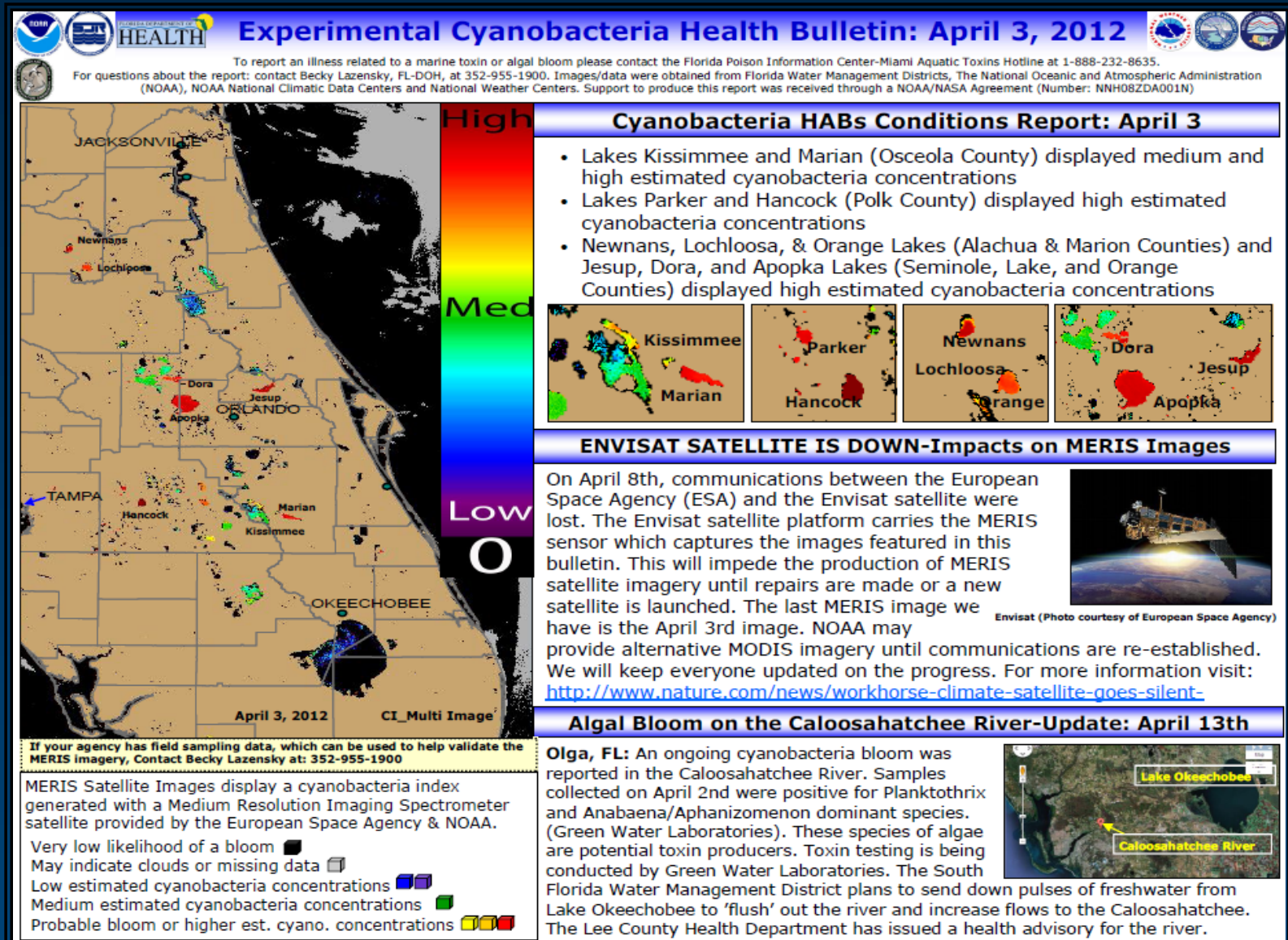
The bulletin's distribution list includes these state and local agencies:

- FDOH -FL-DEP
- CHDs -SJRWMD

Fall 2011, 57 people in Florida subscribed
Spring 2012, 117 people from 15 agencies
subscribe

Now on hold as we work out MODIS option

Satellite Health Bulletins: Example



Page 2: Satellite Health Bulletins

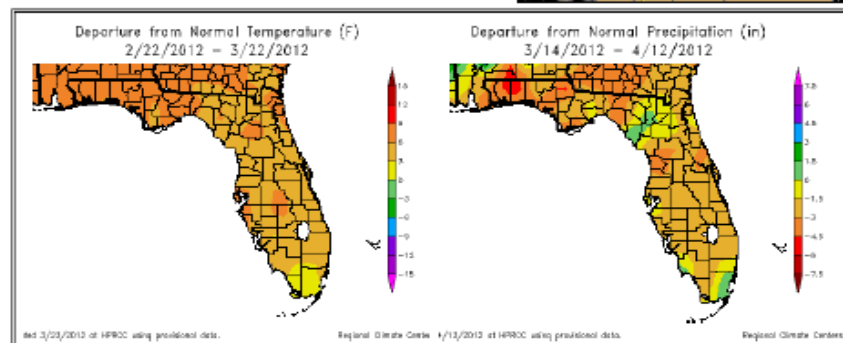
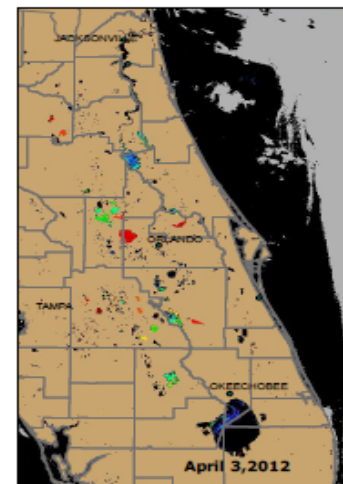
Interpreting Medium Resolution Imaging Spectrometer Satellite Imagery

- The medium resolution imaging spectrometer (MERIS) is located on the Envisat satellite deployed by the European Space Agency.
- The cyanobacterial index algorithm is designed to identify high biomass algal blooms caused by cyanobacteria. However, the current algorithm tends to have false positives, so other blooms may be "flagged". NOAA is currently testing new algorithms that are more specific to cyanobacteria.
- Data can be used to estimate near surface cyanobacteria concentrations which are an indication that algal blooms may be present.
- The algorithms used to generate the satellite images can vary, resulting in some models having a higher likelihood of detecting surface blooms. The satellite identifies the biomass near the surface (in the upper few feet of water). As a result, it may underestimate the total biomass for blooms that are mixed or dispersed through the water column. Turbidity does not otherwise influence the algorithms.
- The satellite imagery does not display the species of algae present.
- While patches of red or warm colors may indicate a bloom, these data have not been verified in most cases using ground-truth methods. Data collected by the satellite is considered experimental.
- Only part of FL is in the satellite's coverage area.
- Several environmental factors may affect how results can be interpreted. For example, areas with abundant aquatic vegetation may present with a high cyanobacteria index on the color spectrum, resulting in a false positive bloom reading.

Weather Conditions: March 14- April 12 Temperature and Precipitation



- Weather conditions can impact the duration and location of blooms and the satellite imagery shown in this report may no longer be relevant. Images represent the last image taken with a realization that blooms may have moved, dissipated or intensified.
- Cloud coverage can obscure imagery and create patches or gray areas on map and obscure bloom detection.



To review HABs satellite reports in the Gulf of Mexico and marine waters visit the NOAA Harmful Algal Bloom Operational Forecast System bulletin archive at: <http://tidesandcurrents.noaa.gov/hab/bulletins.html>



For Individual Weather Station Data Visit:
http://www.serps.com/climateinfo/historical/historical_fl.html

Questions about the report or suggestions: You can contact
Becky Lazensky, MPH
352-955-1900
Becky_Lazensky@doh.state.fl.us



New HABs Tracking Website

In 2012, the FDOH Aquatic Toxins Program developed a new online tracking module for documenting cyanobacteria blooms statewide.

Link to the Caspio Web Hosting Site:

– <http://www.caspio.com/>

HABs Tracking Website

Harmful Algal Bloom Tracking Module

Welcome to the Florida Harmful Algal Bloom (HAB) Online Tracking Module. This site is designed to provide a secure electronic database.

PRIVACY DISCLAIMER: This site should not be used to collect HIPAA protected health information, the name and address of a private citizen or details about a person's health status. This includes submitting health complaints related to a bloom, contact the Florida Department of Health's Aquatic Toxins Division, at: 850-245-4187.

- Format for all dates and times is MM/DD/YYYY and HH:MM AM/PM EST
- Size limit for attachments is 15MB per submission and up to 60MB cumulatively (initial submission only)
- (*) Indicates the field is required

Descriptive Bloom ID*

Format: AgencyName_Date_WaterBody

-Note: Use the name of the agency you represent- Examples: FDOH, CHD, FDEP, FDACS, FWC/F

Name of Water Body

To protect privacy, do not report blooms that occurred in a water body with a single residence located next to it.

Collects information on the location of bloom events, environmental conditions, site visit observations, & laboratory results.

Searchable Database of Bloom Records

Bloom Contact ID

Descriptive Bloom ID

Name of Water Body

Bloom Recorder's First Name

Bloom Recorder's Last Name

Date Record Was Added

Date Record Was Last Modified

Date Bloom Was Sighted

Contains a Searchable Database for Retrieving Data

New HABs Tracking Website

This website allows public health professionals and environmental scientists to collaborate on bloom reporting by populating a shared web-based data page.

The online data page will be used as a repository for HAB-related data and is available to assist with ongoing NOAA/ NASA satellite data validating efforts.

Satellite Imagery Guide for CHDs

A user guide on how data can be applied to public health practice was developed

Examples of possible uses:

- Epidemiologists can include water sites with high a cyanobacteria index when interviewing ill persons about their recent recreational water exposures
- Environmental Health programs may rely upon satellite imagery data when deciding where to conduct field assessments of public swimming areas
- State and local agencies can use imagery to target sampling and educational health interventions

Applications of Satellite Imagery Data

- Informing Public Health Investigations
- Increasing Surveillance
- Identifying Toxin Producing Blooms
- Targeting Sampling Efforts
- Protecting Public Drinking Water

Cyanobacteria Satellite Imagery Uses for County Health Departments

1. **Provides Increased Situational Awareness:** Satellite imagery can provide County Health Departments (CHDs) with a picture of environmental conditions in their county and a view of what is happening statewide. This information can serve as part of an early-warning system to notify counties when conditions are favorable for bloom formation and provides valuable time to prepare education and risk communications materials and inform key stakeholders. Satellite information may be useful during large-scale event planning such as before holidays or events that include recreational water activities to allow for early precautionary measures to be taken like testing the water body before the event.

2. **Informing Public Health Investigations:** Satellite bloom detection will allow CHDs to make important linkages between health complaints in their community and specific health threats. When they know locations of ongoing blooms, CHDs are better equipped to associate illnesses with cyanobacteria exposures. Identifying areas with active algae blooms encourages epidemiologists to inquire whether symptomatic persons swam in the affected water source. While some blooms are considered nuisance blooms, others can cause respiratory, gastrointestinal, and neurological symptoms within a short time following an exposure.

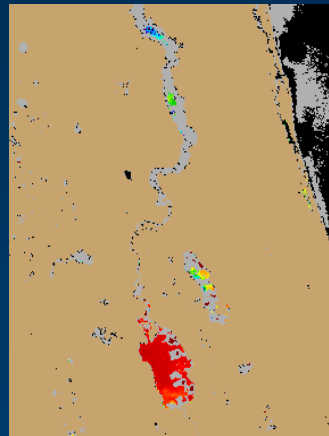
3. **Increasing Surveillance Efforts:** CHDs may share details of recent cyanobacteria blooms with local healthcare providers to improve case finding. When blooms are associated with health effects, CHDs often increase surveillance efforts to identify additional illnesses and implement response activities aimed at reducing health impacts.

4. **Identifying Toxic Blooms by Targeting Sampling Activities:** Satellite imagery can assist in identifying areas which are at an increased risk of cyanobacteria blooms and guide field sampling efforts more effectively. Blooms can then be assessed for toxins which pose a threat to human and animal health. Environmental Health programs can rely upon imagery to provide timely oversight of public swimming areas. Field assessments of permitted freshwater bathing sites can be done when satellite imagery indicates there may be high cyanobacteria concentrations. Collaboration between CHDs and partner agencies such as the Florida Fish and Wildlife Conservation Commission, Florida's five Water Management Districts, and the Department of Environmental Protection) encourages using the appropriate agency's resources to test whether blooms are composed of toxin-producing algal species.

5. **Protecting Public Drinking Water:** Surface water treatment facilities can use satellite imagery as a mechanism to identify blooms that have the potential to affect their source water. The imagery, together with NOAA predictive modeling, provides water facilities time to develop contingency plans for alternate sources of potable water. This would reduce the likelihood that cyanotoxins will enter the public drinking water supply.

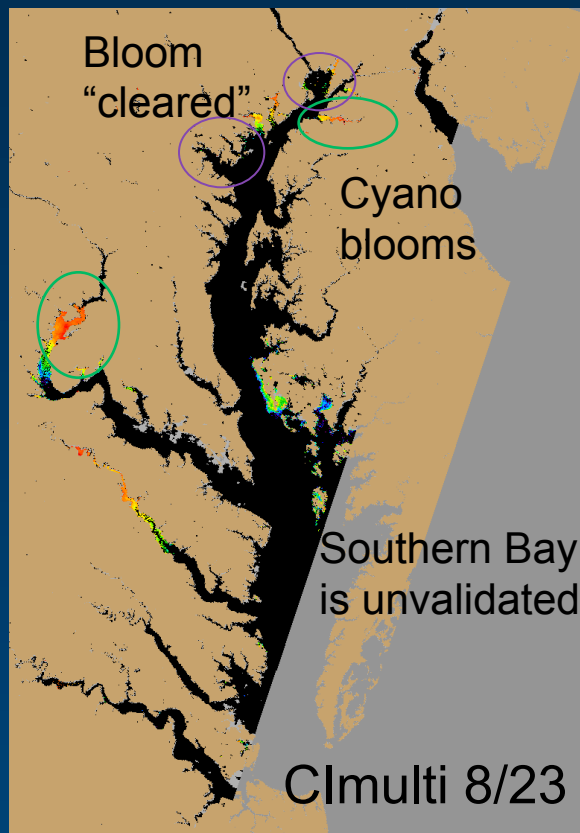
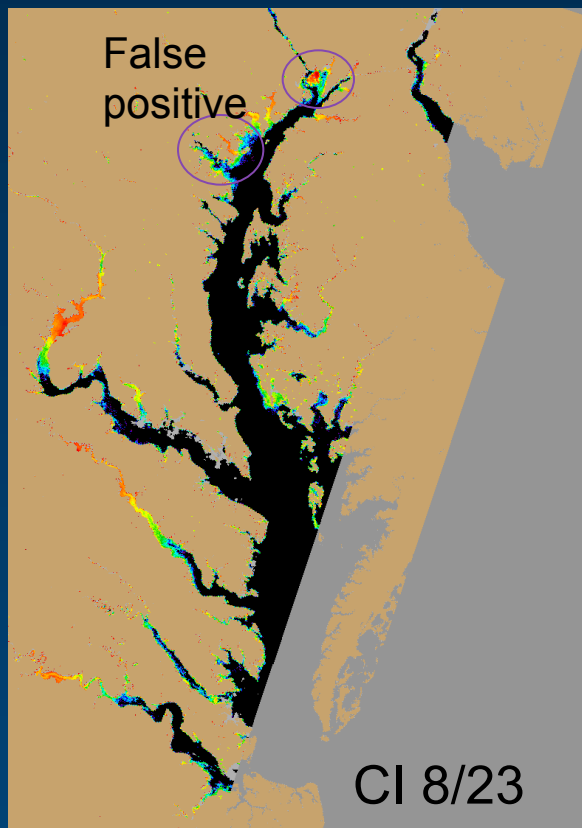
Partnering with the St Johns River Water Management District

- ◆ In 2011-NOAA conducted 2 radiometer trainings w/ 6 SJRWMD and 1 FDOH scientist in March and June
- ◆ Radiometer data were collected from the St Johns River, Lake Apopka, Newnans Lake, Bivens Lake, Lake George, & Crescent Lake
- ◆ *Microcystis* blooms indicated in NOAA satellite imagery were confirmed by local sampling efforts in Crescent & George Lakes



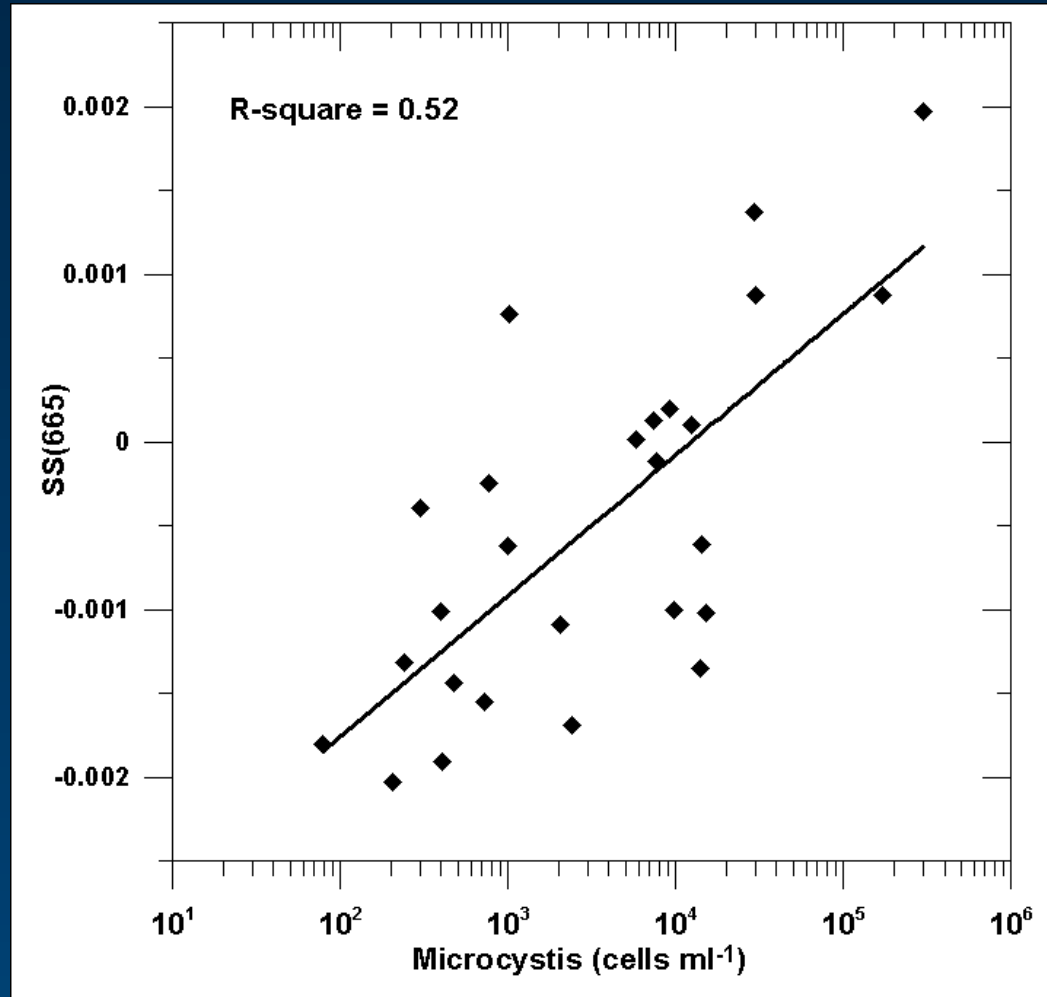
Chesapeake Bay- state interest in satellite data

- CI from Lake Erie produced false positives in Chesapeake
- Revised algorithm, separates cyanos, but does not work for MODIS.



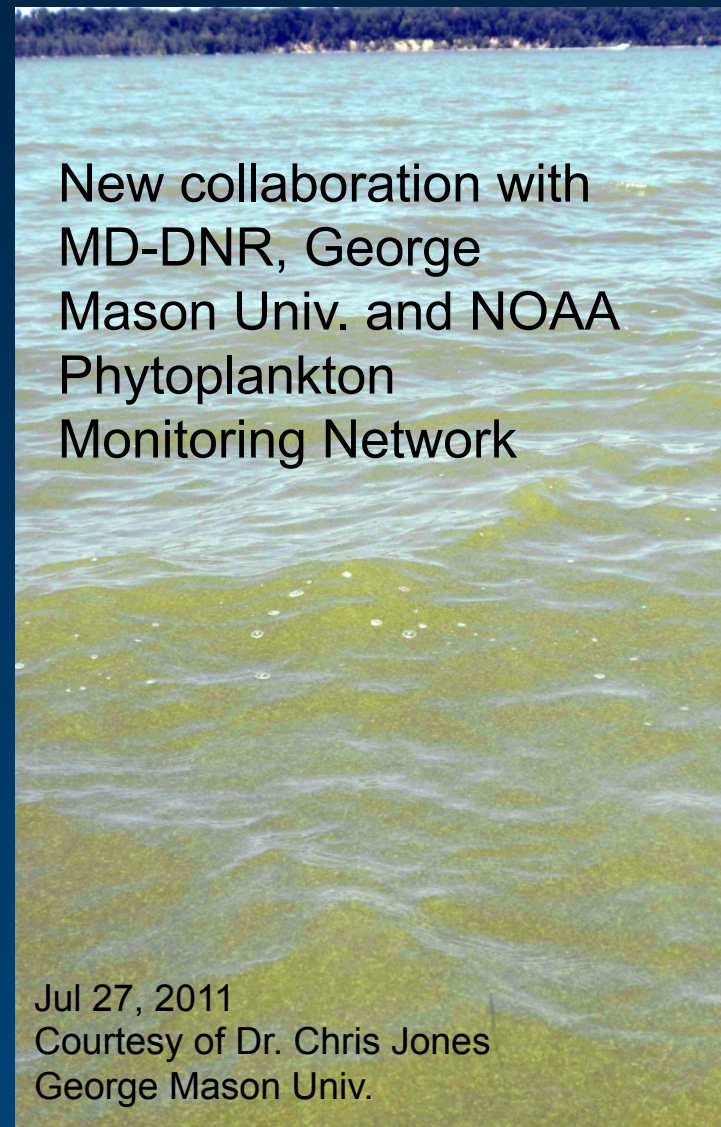
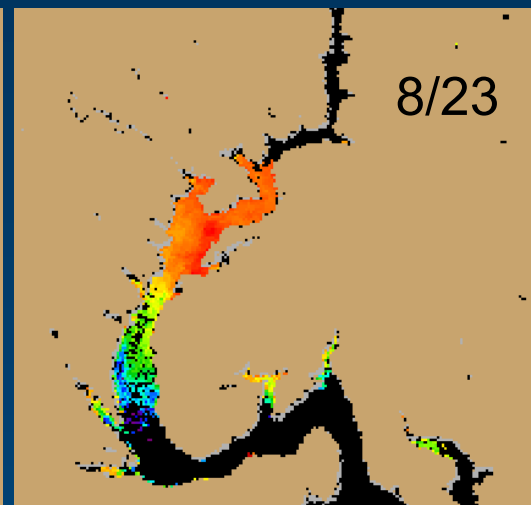
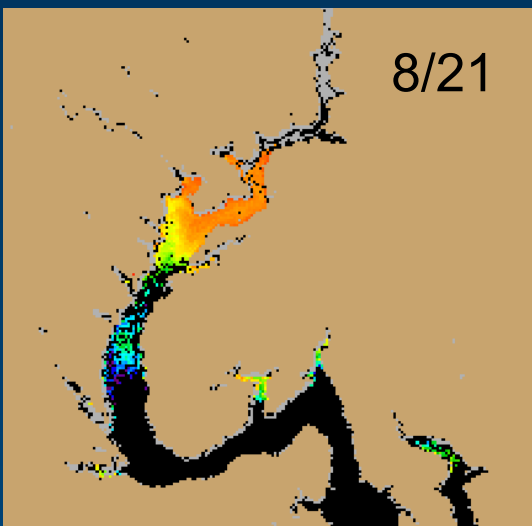
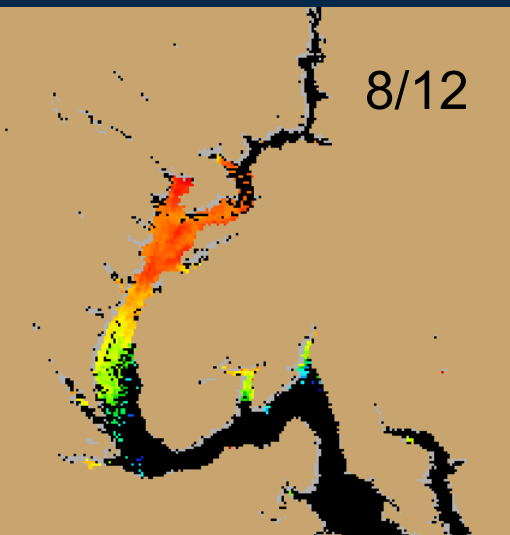
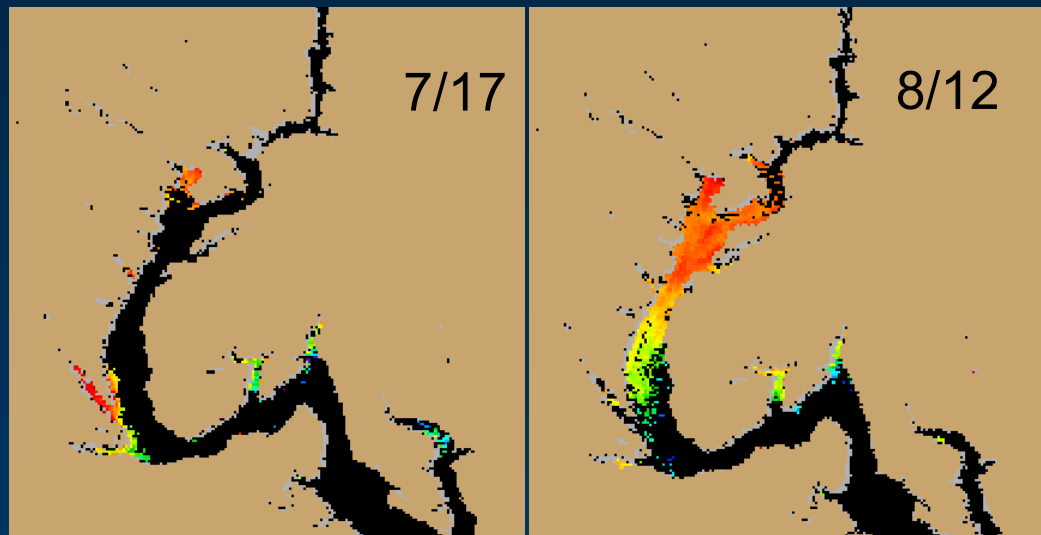
Revised MERIS,
will work with
PACE,
GEOCAPE)

Part of the cyano algorithm; effective with sunglint



Potomac River *Microcystis* bloom

Improved CI



Partner responses

“Looking at the MODIS imagery from today it was a pretty good forecast for the movement of the bloom.

Sure wish you guys could do this several times each week instead of just once, especially this time of year”

Brenda Snyder
Chief Chemist
Toledo Water Treatment

NOAA’s product “ will minimize resources necessary for large scale surveillance. It will help us focus our resources.”

Linda Merchant-Masonbrink
Ohio EPA, Div of Surface Waters. Aug 2011

“The satellite data should provide us with a new way to track the Potomac bloom (spatially and temporally) as it progresses this year.”

Cathy Wazniak, Maryland DNR

3rd Year Successes

- Applied improved cloud mask to image products; improved cyanobacterial index (discrimination of lake cyano blooms)
- Partnered with SJWMD and FDOH, provided training on radiometry; extensive field radiometry, water samples were collected this summer
- MODIS 1-km substitution for MERIS
- Satellite Health bulletin for Northern Florida water management districts until MERIS stop
- Produced weekly forecasts for western Lake Erie blooms (June 9-present); unusual bloom in central lake, mild bloom in western.

Publications

- Stumpf, R.P., T.T. Wynne, D.B. Baker, G.L. Fahnenstiel, 2012. Interannual variability of cyanobacterial blooms in Lake Erie. PLoSONE. 7(8): e42444. doi:10.1371/journal.pone.0042444
- Wynne, T.T., R.P. Stumpf, M.C. Tomlinson, D.J. Schwab, G.Y. Watabayashi, and J.D. Christensen. 2011. Estimating cyanobacterial bloom transport by coupling remotely sensed imagery and a hydrodynamic model. *Ecological Applications*. Vol. 21, No. 7 pp. 2709-2721, [doi: 10.1890/10-1454.1
- Lanerolle, L.W.J., R.P. Stumpf, T.T. Wynne and R.C. Patchen. 2011. A One-Dimensional Numerical Vertical Mixing Model with Application to Western Lake Erie. NOAA Technical Memorandum NOS NCCOS 131. National Oceanic and Atmospheric Administration, National Ocean Service, National Centers for Coastal Ocean Science. Silver Spring, MD. 44 pp.
- Faris, J., Lazensky, B., Reich, A., Stanek, D., Blackmore, C., 2011. Cyanotoxins and the Health Impacts on Pets, Livestock, and Wildlife. The Florida Cattleman, Nov. Ed, pp. 57-65.
- Lazensky, B., Reich, A., Stanek, D., Blackmore, C., 2011. Cyanotoxins and the Health Impacts on Pets, Livestock, and Wildlife. The Advocate Magazine, 4th Ed. pp. 8-11.
- Wynne, T.T., R.P. Stumpf, M.C. Tomlinson, J. Dyble, 2010. Characterizing a cyanobacterial bloom in western Lake Erie using satellite imagery and meteorological data. *Limnology and Oceanography*, v. 55, No. 5, pp. 2025-2036.

Presentations

- Stumpf, R.P., The 2012 Seasonal Forecast of Cyanobacterial bloom in Lake Erie. July 05, 2012. Ohio State University Stone Lab. (with University of Toledo, Heidelberg University).
- Stumpf, R.P. 2012, Interannual Variations in Cyanobacterial Blooms in Lake. EPA Great Lakes NPO, Nearshore/Nonpoint Work Group Webinar.
- Stumpf, R.P., T.W. Wynne, M.C. Tomlinson, G. Fahnenstiel, D.B. Baker, 2012. 10 years of variation in cyanobacteria blooms in Lake Erie. Intl Association of Great Lakes Research 2012 Conference, May 13-17, Cornwall, Ontario, Canada.
- Stumpf, R.P., Monitoring Status, Mid-Atlantic HAB Working Group. Annapolis, MD, December 06, 2011.
- Tomlinson, M.C., R.P. Stumpf, and T.T. Wynne. 2011. Finding and Forecasting Harmful Algal Blooms. The National Shellfisheries Association 103rd Annual Meeting. March 27-31, 2011. Baltimore, MD.
- Neff, C., M.C. Tomlinson, R.P. Stumpf, T.T. Wynne, R. Burks, G. Fahnenstiel. 2011. Bloom characterization of cyanobacteria using radiometry. Poster, Sixth Symposium on Harmful Algae in the U.S. Austin Texas, Nov 13-18, 2011.
- Fisher, K.M., R. Stumpf, M.C. Tomlinson, Operational HAB Forecasting: progress, challenges, and prospects. Talk, Sixth Symposium on Harmful Algae in the U.S. Austin Texas, Nov 13-18, 2011.
- Stumpf, R.P., K. Fisher, Q. Dortch, T. Tomlinson, 2011 Forecasting harmful algal blooms: differences in ecology, commonalities in execution. Talk, Sixth Symposium on Harmful Algae in the U.S. Austin Texas, Nov 13-18, 2011.
- Tomlinson, M.C., T. Briggs, C. Neff, R. Burks, R. Lazensky, C. Hart, A. Reich, H. Raymond, C. Wazniak, R.P. Stumpf, T.T. Wynne, 2011. Monitoring cyanobacterial blooms with full-resolution MERIS imagery to support state management activities. poster, Sixth Symposium on Harmful Algae in the U.S. Austin Texas, Nov 13-18, 2011.
- Stumpf, R.P., 2011. Remote sensing and Modeling of Harmful Algal Blooms, CDC HABISS Annual Users Meeting, Jan 24-25.
- Stumpf, R.P., M.C. Tomlinson, T.T. Wynne, S. Joseph-Joshi, J. Dyble. 2010. Using models to forecast Harmful Algal Blooms, an example from Lake Erie. The Modeling for Public Health Action: From epidemiology to operations, conference. Atlanta, GA Dec 9-10 2010.

Goals for 2013-2014

- Continue outreach: Host user workshop in Florida and Ohio to provide information on how environmental managers, public health programs, and water treatment facilities can use bulletins for management. Update MD-VA HAB Task Force in December
- Transfer a MODIS product into Florida Satellite health bulletin
- Continue to validate blooms, biomass and type, blooms using radiometers and water testing, and aquafluor to screen for increases in chl *a* and phycocyanin
- Spatial climatology for Lake Erie
- Examine Florida lake climatology
- Plan for OLCI, ready distribution through Web and EPA